



# **San Francisco Bay Area Network Vital Signs Workshop Summary Draft**

**March 19-20, 2003  
Golden Gate Club, Presidio, San Francisco**



San Francisco Bay Area Network (SFAN)  
Eugene O'Neil National Historic Site (EUON)  
Fort Point National Historic Site (FOPO)  
Golden Gate National Recreation Area (GOGA)  
John Muir National Historic Site (JOMU)  
Muir Woods National Monument (MUWO)  
Pinnacles National Monument (PINN)  
Point Reyes National Seashore (PORE)  
Presidio of San Francisco (PRSF)

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## 1   **Introduction**

### 3   Monitoring Rationale

4   Knowing the condition of natural resources in national parks is fundamental to the National Park  
5   Service's (NPS's) ability to manage park resources "unimpaired for the enjoyment of future  
6   generations." National Park managers across the country are confronted with increasingly  
7   complex and challenging issues that require a broad-based understanding of the status and trends  
8   of park resources as a basis for making decisions and working with other agencies and the public  
9   for the benefit of park resources. Simultaneously, park managers must provide scientifically  
10   credible information to select and defend management actions and fulfill legal mandates. The  
11   National Parks Omnibus Management Act of 1998, for example, includes a Congressional  
12   mandate for Parks to provide information on the long-term trends in the condition of their natural  
13   resources.

15   In response to these challenges, the NPS has identified 270 parks with significant natural  
16   resources for which inventories will be completed and long-term ecological monitoring will  
17   occur. Natural resource monitoring provides site-specific information needed to understand and  
18   identify change in complex, variable, and imperfectly understood natural systems and to  
19   determine whether observed changes are within natural levels of variability or may be indicators  
20   of anthropogenic influences. This broad-based, scientifically sound information can then find  
21   application in management decision-making, research, education, and promotion of public  
22   understanding of park resources.

24   The intent of the NPS monitoring program is to track a subset of park resources and processes,  
25   known as "vital signs," that are determined to be the most significant indicators of ecological  
26   condition for specific resources that are of greatest concern to each park. Because of the  
27   tremendous variability among parks in ecological condition, size, and management capabilities,  
28   it has been recognized that adoption of a "one size fits all" design is not an effective monitoring  
29   approach for the NPS. Rather, parks have been given the flexibility to integrate inventory and  
30   monitoring programs into existing park operations and management agendas to facilitate  
31   efficiency and cost-effectiveness. Parks also have been encouraged to incorporate partnerships  
32   with external agencies and institutions into the Vital Signs Monitoring Program to effectively  
33   understand and manage resources and threats that extend beyond park boundaries.

### 36   Service-wide Vital Signs Monitoring Goals

37   Despite the differences that exist among parks, five Service-wide Goals for Vital Signs  
38   Monitoring have been established for the National Park Service. While no single piece of  
39   legislation specifically defines these monitoring goals, they are derived from the mandates of the  
40   National Parks Omnibus Management Act of 1998 and the goals established by prototype  
41   monitoring parks and the long-term ecological monitoring program. These goals are to:

- 42       ❑ Determine status and trends in selected indicators of the condition of park ecosystems to  
43       allow managers to make better-informed decisions and to work more effectively with  
44       other agencies and individuals for the benefit of park resources.

- ❑ Provide early warning of abnormal conditions and impairment of selected resources to help develop effective mitigation measures and reduce costs of management.
- ❑ Provide data to better understand the dynamic nature and condition of park ecosystems and to provide reference points for comparisons with other, altered environments.
- ❑ Provide data to meet certain legal and Congressional mandates related to natural resource protection and visitor enjoyment.
- ❑ Provide a means of measuring progress towards performance goals.

#### Steps to Developing a Network Monitoring Program

The 270 parks identified for the Inventory and Monitoring Program have been grouped into 32 vital sign networks linked by geography and shared natural resource characteristics. Each network of parks is required to design an integrated monitoring program that addresses the monitoring goals listed above and that is tailored to the high-priority monitoring needs and partnership opportunities for the parks in that network. The basic approach to designing a monitoring program should follow five basic steps, which are further discussed in the [Recommended Approach for Developing a Network Monitoring Program](#):

1. Define the purpose and scope of the monitoring program.
2. Compile and summarize existing data and understanding of park ecosystems.
3. Develop conceptual models of relevant ecosystem components.
4. Select indicators and specific monitoring objectives for each; and
5. Determine the appropriate sampling design and sampling protocols.

Monitoring program development is an iterative process. As a network's monitoring program evolves, management issues and monitoring objectives may change to accommodate increased understanding of ecological processes, ecosystem conditions, and human interactions with the environment. Likewise, improvements in technology may alter the ability to assess ecological change. Consequently, a network's conceptual models most likely will be refined, and sampling design and protocol may be adjusted to reflect advances in understanding and technology. This process is an integral part of an adaptive management approach.

#### Peer Review

Peer review is a key component of a successful network monitoring program. Monitoring program materials should be critiqued by park managers, subject experts, and interested stakeholders within the NPS and from external agencies and institutions. Critical input, suggestions, and understanding gained from peer review ensures that monitoring meets the most critical information needs of each park and produces scientifically credible results that are clearly understood and accepted by scientists, policy makers, and the public. A standard procedure for peer-review will be developed by the network with guidance from the national program.

#### Document Purpose

1 This document summarizes the process used and the products gained from a Vital Signs  
2 Monitoring Workshop conducted by the San Francisco Bay Area Network Parks. The workshop  
3 was designed to review conceptual models and proposed indicators, provide an initial indicator  
4 prioritization, and collect preliminary sampling information for high priority indicators. Key  
5 points from both large and small group discussions, comments, and suggestions are included in  
6 this summary.

## 7 8 9 **Background**

### 10 11 The San Francisco Bay Area Network (SFAN)

12 The San Francisco Bay Area Network (SFAN) is one of eight networks formed in October 2000  
13 in the Pacific West Region of the National Park Service. The SFAN is composed of eight park  
14 units: Eugene O'Neill National Historic Site (EUON), Fort Point National Historic Park  
15 (FOPO), Golden Gate National Recreation Area (GOGA), John Muir National Historic Site  
16 (JOMU), Muir Woods National Monument (MUWO), Pinnacles National Monument (PINN),  
17 Point Reyes National Seashore (PORE), and the Presidio of San Francisco (PRSF). FOPO,  
18 GOGA, MUWO, and PRSF are administered as one unit by GOGA. EUON and JOMU are  
19 managed jointly. PRSF and EUON were not originally selected by WASO as part of the 270  
20 parks nationwide with significant natural resources; however, the SFAN steering committee  
21 decided that natural resource issues within these parks were sufficient to be included in the  
22 network. The SFAN was selected as one of the first three networks in the region to obtain  
23 monitoring funds because of need, capacity, and existing monitoring effort.

### 24 25 26 Network Setting and Ecological Significance

27 The abundance and diversity of ecosystems and taxa in the SFAN are remarkable, owing to the  
28 Mediterranean climate, convergent oceanic currents, topographic variation, and overlapping  
29 ecological regions.

30  
31 The moderate Mediterranean climate offers long growing seasons and supports diverse plant and  
32 animal communities, including over 1200 plant species. Important vegetation alliances include  
33 coastal dune, coastal terrace prairie, serpentine chaparral and bunchgrass, chaparral, native  
34 grasslands, oak woodland, ancient redwood forests, Bishop pine forests, and Douglas-fir forests.  
35 Nearly 60 federal or state listed threatened and endangered species occur as residents or seasonal  
36 migrants.

37  
38 The convergence of oceanic currents rising from the abyssal plain over a steep canyon makes the  
39 marine and coastal shoreline habitats complex and diverse. The California coast is one of only  
40 five areas of eastern boundary upwelling oceanic currents worldwide. In addition, a plume of  
41 warmer, freshwater exiting the San Francisco Bay extends out into the Gulf of the Farallones.  
42 These nutrient rich waters support an abundant and diverse fauna. More than one-third of the  
43 world's cetacean species occur in these waters. Significant haul-out areas for five species of  
44 pinnipeds are used year round and represent one of only eleven mainland breeding areas for  
45 northern elephant seals in the world and 20% of the mainland breeding population of harbor  
46 seals in California. Eleven species of seabirds breed within the parks and over 80 waterbird and

shorebird species were identified in the parks during the 1997-99 inventories (Kelly and Etienne 1999).

Elevation across the parks ranges from sea level to 3,300 feet above mean sea level. The San Andreas Fault, the dominant geological force in this area, is a source of natural disturbance in the form of seismic activity resulting from interaction of the Pacific and the Continental Plates. This geologic activity re-structures ecosystems offering unusual habitat for endemics and species at the edge of their range as coastal California from Pinnacles through Point Reyes slides northward. Plate movement created and continues to create a fractured landscape with unique geology and soil types. Volcanic activity created the Pinnacles rock formations, and plate tectonics thrust the rock spires upward. Associated cave formations provide habitat for many unique species. Slopes range from almost flat marine terraces and alluvial deposits to steep canyons along some creeks, providing dramatic topographic and, therefore, habitat heterogeneity. Consequently, the SFAN parks are located within three terrestrial ecological regions:

1. The Central California Coast contains coast live oak, chamise, valley oak, redwood, Douglas fir-tanoak, chaparral and grassland series of vegetation communities,
2. The Northern California Coast contains redwood, Douglas fir-tanoak, coast live oak, chaparral, and grassland series; and
3. The Central California Coast Range contains coast live oak, chamise, valley oak, and mixed chaparral series (Bailey 1994).

The SFAN parks represent an area designated as one of the six most significant in the nation for biodiversity (The Nature Conservancy 2000). Notably, the parks support endemic species and communities despite close proximity to large urban areas and are listed as the eighth most significant “hot spot” in the world for biodiversity at risk from rapid human population growth (Cincotta and Engleman 2000). With a current population of 6.9 million, the metropolitan centers of San Francisco, Oakland, and San Jose are forecast to have a population of 8 million by 2020 (Assoc. of Bay Area Governments 2000). Recognizing the extraordinary significance and exposure to threats in the region, the UNESCO Man in the Biosphere program designated the Central California International Biosphere Reserve in 1988, encompassing five of the eight parks. Preserving biologically and geologically diverse habitats and their associated species, as well as providing opportunities for recreation, education, and aesthetic enjoyment to a large urban population, is a difficult balancing act. The need to mitigate impacts and preserve these natural resources based on scientific recommendations from a wisely developed monitoring program is urgent.

#### Previous Monitoring Workshops

In 1993 prior to the formation of park networks, the resource management staffs from the GOGA and PORE park cluster decided to develop a comprehensive Inventory and Monitoring (I&M) Program. These parks had separately developed I & M projects for single species or species groups such as rare plants, pinnipeds, migratory raptors, and exotic plants. Also, GOGA had independently developed an ecological monitoring program in coastal scrub and grassland

1 habitats in 1988 (Howell 1992). None of the parks, though, had initiated an integrated ecological  
2 monitoring program.

3  
4 The parks coordinated efforts to identify and complete several of the design elements identified  
5 in the I&M program developed by Gary Davis for the Channel Islands National Park prototype  
6 program given Channel Islands' similar ecosystems and its monitoring experience.

7  
8 A draft inventory and monitoring plan was developed in 1996 at the end of this process but was  
9 only partially implemented because of lack of funds. With the initiation of the Natural Resource  
10 Challenge, the GOGA/PORE draft plan was resurrected and modified during an I&M scoping  
11 workshop in July 2002.

12  
13 The SFAN held three Vital Signs Monitoring Workshops in FY02. PINN held a workshop in  
14 September 2001 (Appendix A). EUON and JOMU jointly held workshops in January and  
15 August 2002 since both parks are in close proximity, have similar natural resources and issues,  
16 and are administered jointly (Appendix B). Because of their previous collaborative efforts and  
17 the overlap in resources and management issues, the parks administered by GOGA and PORE  
18 jointly held a workshop in July 2002 (Appendix C). In each of these workshops, participants  
19 identified significant resources in the parks, identified key processes and stressors affecting the  
20 parks, potential monitoring questions, and recommended Vital Signs indicators that could  
21 address the monitoring questions. An initial prioritization of Vital Signs indicators and  
22 development of a conceptual model also were addressed. Participants included Park Service  
23 managers and staff, external natural resource managers, and scientists.

24  
25 Subsequently, the SFAN Steering Committee integrated the findings and recommendations from  
26 the separate workshops into a conceptual model for the network that includes significant natural  
27 resources, key processes and stressors, and monitoring questions with suggested indicators. The  
28 SFAN Vital Signs Workshop held March 19-20, 2003, was organized to review the SFAN  
29 integrated model and its related components and move forward with the selection of network-  
30 wide Vital Signs indicators.

### 31 32 33 SFAN Monitoring Program

34 The five aforementioned NPS Service-wide monitoring goals provide the overall direction for  
35 the SFAN monitoring program. The SFAN Vital Signs Workshop was a step toward reaching  
36 these goals. In part, the workshop considered:

- 37  
38 1. Present and future ecosystem condition,  
39 2. Empirically normal limits of resource variation,  
40 3. Early diagnosis of abnormal condition, and  
41 4. Potential agents of abnormal anthropogenic change.  
42  
43

## SFAN Vital Signs Workshop Objectives (March 2003)

The three main objectives for the March 2003 Vital Signs Workshop were to:

1. Review and critique the SFAN integrated conceptual models,
2. Review and critique the proposed indicators (general and specific),
3. Provide an initial indicator prioritization based on stressor relationships, and
4. Provide information relevant to indicator selection (e.g., methods, expertise, references, and threshold values).

Additionally, indicator prioritization activities were designed to collect preliminary sampling information for high priority indicators.

## **Vital Signs Workshop Framework**

### Selection of Workshop Participants

Workshop participants were selected from lists of previous park-based workshop attendees. Both park and non-park representatives were selected to include other federal agencies, state agencies, and scientists that have had research and management interests within or adjacent to the parks. Among some of these groups, diverse fields of expertise were targeted. The number of participants was limited to approximately 40-50 individuals to facilitate productive and efficient discussions in both large and small work groups. A list of participants and their affiliations can be found in Appendix D.

### Website Postings and Workshop Materials

Upon invitation, participants were notified that workshop materials would be posted to the SFAN website prior to the workshop and available for review. These documents included:

- A workshop agenda,
- A list of participants,
- Directions to the workshop,
- Introductory materials and Network Conceptual Models,
- Individual park Vital Signs Workshop Summaries,
- A list of management issues and monitoring questions,
- Tables of general indicators and related stressors for each resource realm,
- Indicator ranking criteria,
- A sampling protocol questionnaire with definitions and examples,
- An Inventory and Monitoring timeline, and
- A network map.

Color-coded handouts were given to participants at the workshop with a different color corresponding to each workshop objective and discussion session. Upon arrival, participants received:

- A workshop agenda,
- Introductory materials (I&M justification and model definitions),
- The generalized conceptual model,
- Spatial scale representations,
- Ecosystem conceptual models (marine, aquatic/wetland, terrestrial), and
- A conceptual model example for a specific indicator (prairie falcon).

At the end of the first day, the handouts for the second day's activities were distributed (Appendix E). Participants received:

- Tables of general indicators and related stressors for each resource realm,
- A list of management issues and monitoring questions,
- Indicator ranking criteria,
- A list of specific indicators, and
- A sampling protocol questionnaire with definitions and examples.

#### Vital Signs Workshop Format and Agenda

The SFAN Vital Signs Monitoring Workshop was an essential step in the synthesis of a Network Monitoring Program, providing the opportunity for the SFAN to present initial materials for its program development in a public forum for peer review. Workshop sessions designed to promote progress toward a network-wide monitoring program were organized around the three workshop goals. Five sessions were spread over one and one-half days and included:

1. Background and orientation to NPS I&M Program and the SFAN parks,
2. Review and criticism of the SFAN integrated conceptual models,
3. Review and criticism of the proposed indicators,
4. An initial indicator prioritization based on stressor-indicator relationships, and
5. Discussion of indicator protocols.

The terms "indicators" and "vital signs" were used synonymously throughout the workshop to refer to any measurable feature of the environment that provides insights into changes in the state of the ecosystem (see Glossary of Workshop Terms).

Forty-six participants attended the first day of the workshop. A few of these participants were unable to attend the second day's session whereas four new participants attended the second day's sessions only. Many of the participants have been actively involved in the I&M Program at the park level, but a few participants were new to the NPS I&M process. To ensure that all participants were familiar with the Program, an overview of the NPS Inventory and Monitoring Program was presented by the Regional Coordinator as part of the opening session. Similarly, a brief description of the individual parks within the network and a synopsis of the management issues confronting the parks were presented on the first day to provide context for the workshop sessions.

1 The SFAN integrated conceptual model and associated definitions were presented to the entire  
2 group as part of the initial session. The SFAN model is hierarchical, with each layer of the  
3 model becoming increasingly more specific. The SFAN model presented includes:

- 4
- 5 1. A general conceptual model,
- 6 2. Three ecosystem models representing the dominant ecosystem types in the network--  
7 marine, terrestrial, and aquatic/wetland ecosystems, and
- 8 3. A matrix representing the relationship between drivers and stressors and general indicator  
9 categories grouping similar ecosystem components and processes.
- 10

11 Coarse indicator categories were used at this level of the model to create indicators that were  
12 more comparable for ranking purposes. As the program develops, more refined diagrams will be  
13 created depicting understood and hypothesized relationships between drivers/stressors and  
14 specific indicators selected for monitoring purposes. Based on these fine-scale layers of the  
15 model, specific indicators can be ranked from a subset of high-priority, general indicator  
16 categories. Nested spatial and temporal scale diagrams also were included to emphasize the  
17 importance of selecting indicators that may be used to evaluate ecosystem integrity at various  
18 levels of ecological organization.

19

20 After an orientation to the I&M Program, the SFAN parks, and the SFAN Conceptual Model,  
21 participants were placed into one of three ecosystem discussion groups the first afternoon based  
22 on the individual's area of expertise (marine, terrestrial, or aquatic/wetland ecosystems). Groups  
23 ranged in size from six to twelve people including group leaders and recorders. Ecosystem  
24 groups reviewed the general conceptual model and the ecosystem model relevant to their  
25 discussion group. Discussion comments, criticisms, and suggestions were recorded on flip charts  
26 to facilitate group discussion and electronically for reporting purposes.

27

28 On the second day, SFAN management issues and monitoring questions were presented to link  
29 the conceptual model diagrams discussed on the previous day to the driver/stressor-indicator  
30 matrix being reviewed that same day. For the sake of clarification, general indicator categories  
31 and specific indicators were differentiated. Ranking criteria that would be used throughout the  
32 indicator selection process were defined. Generally, indicators would be ranked based on their  
33 management significance, ecological significance, and cost-effectiveness. The day's workshop  
34 activities were outlined as well.

35

36 For the second day's discussion sessions, participants were organized into groups representing  
37 their expertise in one of four resource realms—atmosphere/lithosphere, hydrosphere, biosphere  
38 (faunal group), or biosphere (vegetative group)—as defined by the SFAN conceptual model (see  
39 Glossary of Workshop Terms). The atmosphere and lithosphere realms were combined because  
40 of a limited number of participants with the required expertise. Conversely, the biosphere group  
41 was divided in two because of the large number of participants within this field of expertise.  
42 Work groups ranged in size from six to twelve people.

43

44 The initial task was to review the relationships between the various drivers and stressors listed in  
45 the model and the proposed general indicator categories, revising the matrix as necessary.  
46 Participants also were requested to evaluate the relative strength of these relationships to assist in

1 prioritizing general indicator categories. General indicator categories with the greatest number  
2 of strong, scientifically valid relationships to ecosystem drivers and stressors were the highest  
3 priority. Because of a variety of conceptual problems associated with the stressor/general  
4 indicator matrix, none of the discussion groups adhered to this process. Ranking was conducted  
5 by each group, but different methodologies were used.

7 Discussions in the afternoon were devoted to prioritizing specific indicators from among the  
8 high-priority general indicator categories discussed in the morning. Ideally, protocol  
9 questionnaires detailing sampling and monitoring information were completed for each specific  
10 indicator found to be a priority within each resource realm. Again, difficulties encountered  
11 earlier in the process led to different approaches to ranking specific indicators and completing  
12 questionnaires. Nevertheless, the tasks were accomplished.

14 Small group reports and a workshop summary were used to bring closure to the workshop at the  
15 end of each day. The Workshop Agenda can be found in Appendix F.

17 Following the workshop, steering committee members and NPS contributors met to review the  
18 workshop process and products and to discuss future needs and assignments of the SFAN I&M  
19 program.

### 22 Ecological Conceptual Models

23 An ecological conceptual model is a visual or narrative summary that describes the important  
24 components of an ecosystem and the interactions among them. Development of a conceptual  
25 model helps in understanding how the physical, chemical, and biological elements of a  
26 monitoring program interact, and promotes integration and communication among scientists and  
27 managers from different disciplines. Ecological conceptual models also need to define relevant  
28 spatial and temporal scales to provide an appropriate context for the ecosystem components and  
29 processes being considered. Conceptual model development is an iterative and interactive  
30 process. Models are expected to change as a network's monitoring program develops and as  
31 ecological linkages are better understood. Details will be added to models after indicators have  
32 been selected and prioritized.

### 35 General Conceptual Model

36 A generalized conceptual model was presented to workshop participants to introduce the  
37 organizational structure of model subcomponents (Appendix E). For conceptual purposes,  
38 ecosystems within the SFAN were divided into three types--marine, wetland, and terrestrial—  
39 with each ecosystem type having associated subsystems or forms. Ecosystems were further  
40 divided into dominant resource realms (atmosphere, biosphere, hydrosphere, and lithosphere) to  
41 assist in organizing similar ecosystem processes and components. Key natural processes  
42 (drivers) and anthropogenic stressors are also represented in this model acting on the different  
43 ecosystems along pathways associated with each resource realm. Note that socio-political forces  
44 influence anthropogenic stressors.

## Ecosystem Models

Individual conceptual models were presented for each ecosystem type. Represented in each model are the dominant ecosystem drivers and anthropogenic stressors proposed for the SFAN. Natural and anthropogenic forces produce changes in ecosystem processes and components through their interactions with the forms associated with each ecosystem. Example effects resulting from these interactions are listed in the models. Examples of broad-scale indicators that may assist in monitoring the effects of ecosystem drivers and anthropogenic stressors on ecosystems also are depicted in the models. Indicators are organized by resource realm and ecosystem form. Note that the Biosphere realm is subdivided to reflect the need to monitor different levels of ecological organization. Ecosystem models are included in Appendix E.

## Management Issues and Monitoring Questions

The SFAN's significant management issues and corresponding monitoring questions were tabulated and presented to workshop participants (Appendix E). Monitoring questions (or objectives) were generated in previous I&M scoping workshops and through discussions with park staff. Monitoring questions direct managers and scientists toward the selection of indicators that will not only assist scientists in assessing the ecological integrity of park ecosystems but will also aid decision makers in addressing the parks' management issues. Thus, monitoring questions provide a link between management issues and ecological indicators.

## Stressor/General Indicator Matrix

Potential relationships between broad-scale (general) indicators and drivers and anthropogenic stressors were presented in matrix format (Appendix E). General indicators were organized by resource realm and by category (e.g., air quality, water quality, disturbance events) along the vertical axis. Drivers and stressors were aligned along the horizontal axis. An "x" was placed in any box where an indicator intersected with a driver or stressor with which there existed a potentially significant relationship. Information collected from previous scoping workshops, inventory study plans, resource management plans, and from discussions with resource managers was used to construct the matrix. The parks for which these relationships held potential application also were noted. General indicators rather than specific indicators were used to limit the model's complexity and to simplify the initial indicator prioritization process for this layer of the model. The intent was to compare general indicators qualitatively by assessing the relative strength and validity of the relationships established in the matrix for each indicator.

## Specific Indicators

Each participant was provided with a list of specific indicators (Appendix E). For each general indicator within a given resource realm, relevant specific indicators were listed along with a list of parks in which the indicators could be applied. Appropriate ecosystem types also were listed. Indicator lists were compiled from previous scoping workshops, inventory study plans, and resource management plans. It will be necessary to design more detailed conceptual models focusing on high priority indicators (Vital Signs) in the future. An example of a conceptual model for a specific indicator (prairie falcon) is included in Appendix E.

## Criteria for Indicator Selection

Participants were asked to consider three criteria when prioritizing general and specific indicators: management significance, ecological significance, and cost effectiveness. Criteria for the SFAN follow Tegler and others (2001) and were defined for participants during the workshop (Appendix E). A refined version of these criteria will be used by the SFAN steering committee and park staff in the final prioritization process.

## Protocol Questionnaire

Resource realm working groups were asked to complete protocol questionnaires for each of the high priority indicators identified by their group. Essential information requested on the questionnaire includes: indicator name, ecosystem type, metric, methods (including frequency, timing and scale), basic assumptions, constraints, and references. Appendix E contains definitions for questionnaire categories and an example. Information obtained from completed questionnaires will be used in future prioritization steps and to develop monitoring protocols.

## **Workshop Session Summaries and Revisions**

The following information summarizes the comments and suggestions captured in the SFAN Vital Signs Monitoring Workshop. Comments and revisions are organized by discussion group and according to the workshop agenda. More detailed comments were recorded throughout the workshop.

### Ecosystem Discussion Groups

#### General Conceptual Model Comments

Ecosystem discussion groups found the General Conceptual Model to be acceptable with minor revisions. Most suggestions addressed stylistic or organizational issues. Several reviewers recommended that the model was too general and that a network boundary needed to be defined to differentiate it from others. Reviewers also recommended that specific reference to local components and processes be made (e.g., Mediterranean climate instead of climate). Feedback loops also should be represented in the model.

## Marine Ecosystem Model Revisions

Note: The boundary for marine ecosystems should extend beyond the NPS's ¼ mile limit.

### *Revised List of Drivers*

- Climate/Weather
- Oceanographic Processes
- Biological Processes & Species Interactions
- Coastal Processes
- Geologic Processes
- Hydrology
- Disturbance
- Nutrient Cycles

### *Revised List of Stressors*

- Altered Water/Air Quality
- Habitat and Population Fragmentation
- Disturbance
- Invasive Alien Species
- Unsustainable Use
- Disease

This group ranked the relative importance of the drivers and stressors:

High:	Climate, Disturbance, Hydrology (bays and estuaries), Nutrient Cycles (bays and estuaries), Oceanographic Processes, Biological Processes and Species Interactions
Medium:	Coastal Processes
Low:	Geologic Processes, Hydrology, Nutrient Cycles

### *Revised List of Forms*

Ocean	Soft bottom
	Hard bottom
	Sea mounts
	Islands
	Canyons
	Persistent Oceanographic Features
Intertidal	Rocky Intertidal
	Sandy Beach
Bay Estuary	Mudflats
	Salt Marshes
	Mouth of Estuaries

### *Indicator Revisions*

No revisions were suggested for indicators.

1  
2  
3 Wetlands/Aquatic Ecosystem Model Revisions

4 *Revised List of Drivers*

5 Climate/Weather  
6 Biological Processes and Species Interactions  
7 Coastal Processes  
8 Geologic Processes  
9 Hydrology  
10 Disturbance  
11 Nutrient Cycles  
12

13 *Revised List of Stressors*

14 Light Pollution  
15 Noise Pollution  
16 Water Quality Degradation  
17 Air Quality Degradation  
18 Altered Disturbance Regimes  
19 Climate Change  
20 Disease  
21 Engineered Structures  
22 External Development/Demographic Change  
23 Fire Management  
24 Habitat Fragmentation/Alteration  
25 Land Use Change  
26 Non-native Invasive Species  
27 Nutrient Enrichment  
28 Park Development/Operations  
29 Park Management  
30 Recreational Use  
31 Resource Extraction/Introduction  
32 Water Quantity Alteration  
33

34 *Revised List of Forms*

35 Running Water      Streams  
36                              Rivers  
37  
38 Standing Water      Lake  
39                              Pond  
40                              Vernal Pool  
41                              Wetland  
42  
43 Groundwater      Seeps  
44

1 *Indicator Revisions*

- 2 Add Ground Subsidence to Lithosphere
- 3 Add Hydroperiod to Hydrosphere
- 4 Add Water Table to Groundwater
- 5 Add Wetland Distribution to Landscape under Groundwater

8 Terrestrial Ecosystem Model Revisions

9 *Revised List of Drivers (Natural Processes)*

- 10 Climate/Weather
- 11 Coastal Processes
- 12 Biological Processes and Species Interactions
- 13 Tectonic Processes
- 14 Surficial Processes
- 15 Hydrology
- 16 Disturbance
- 17 Nutrient Cycles

19 *Revised List of Stressors*

- 20 Air Quality Degradation
- 21 Altered Disturbance Regimes
- 22 Climate Change
- 23 Disease
- 24 Engineered Structures
- 25 External Development/Demographic Change
- 26 Fire Management
- 27 Habitat Fragmentation/Alteration
- 28 Land Use Change
- 29 Non-native Invasive Species
- 30 Nutrient Enrichment
- 31 Park Development/Operations
- 32 Park Management
- 33 Recreational Use
- 34 Resource Extraction/Introduction
- 35 Water Quality Degradation
- 36 Water Quantity Alteration
- 37 Native Species Extirpation
- 38 Lack of Public Understanding/Awareness
- 39 Legal Changes
- 40 Indigenous Land Management Practices

42 *Revised List of Forms*

- 43 Grasslands
- 44 Shrublands
- 45 Woodlands
- 46 Unique Habitats

1  
2 *Indicator Revisions*

3 Consolidate boxes with redundant indicators  
4 Add Seasonal Flux to Hydrosphere  
5 Add Genetic Variation to Population Level  
6 Change Light Pollution to Light Quality  
7 Add Meta-population Dynamics and Habitat Arrangement to  
8 Landscape box under Unique Habitats  
9

10  
11 Resource Realm Discussion Groups

12 Two different approaches were used by discussion groups to evaluate the relationship between  
13 drivers and stressors and potential indicators. Biosphere groups selected the most significant  
14 drivers and stressors for each indicator, whereas the Atmosphere/Lithosphere and Hydrosphere  
15 groups identified significant indicators for dominant drivers and stressors. Not all drivers,  
16 stressors, and indicators were evaluated. Scale limitations and other selection parameters were  
17 defined by individual groups. In addition to the driver and stressor changes suggested by  
18 ecosystem discussion groups, resource realm discussion groups recommended combining Park  
19 Management and Park Development, combining External Development and Land Use, and  
20 adding Soil Alteration.  
21

22  
23 Biosphere—Faunal Group

24 *Revised General Indicator List*

25 Species Distribution and Abundance  
26 Native Species of Special Interest  
27 Species at Risk  
28 Exotic Species/Disease  
29 Patch Size and Proximity  
30 Community Area and Distribution  
31 Land Use Patterns  
32  
33

34 *Dominant Drivers and Stressors*

35 For each faunal indicator, the dominant drivers and stressors are listed by ecosystem.  
36

37 Species Distribution and Abundance

38 Marine Ecosystems:

39 Drivers--Climate/weather, natural disturbance, biological processes  
40 Stressors—Altered disturbance regimes, engineered structures, habitat  
41 alteration, non-native invasive species, resource extraction/introduction,  
42 water quality degradation  
43

1 Terrestrial Ecosystems:

2 Drivers—Climate/weather, natural disturbance, biological processes

3 Stressors—Altered disturbance regimes, habitat alteration, external

4 development/land use change, non-native invasive species, park

5 development and management, water quantity alteration

6  
7 Aquatic/Wetland Ecosystems:

8 Drivers—Climate/weather, natural disturbance, nutrient cycles,

9 biological processes

10 Stressors—Engineered structures, habitat alteration, non-native

11 invasive species, nutrient enrichment, water quality degradation,

12 water quantity alteration

13  
14 Native Species of Special Interest

15 Marine Ecosystems:

16 Drivers--Biological processes

17 Stressors—Engineered structures, habitat alteration, non-native

18 invasive species, resource extraction/introduction, water quality

19 degradation

20  
21 Terrestrial Ecosystems:

22 Drivers—Climate/weather, biological processes

23 Stressors—Altered disturbance regimes, habitat alteration, external

24 development/land use change, non-native invasive species, park

25 development and management, water quantity alteration

26  
27 Aquatic/Wetland Ecosystems:

28 Drivers—Biological processes

29 Stressors—Engineered structures, habitat alteration, non-native

30 invasive species, nutrient enrichment, water quality degradation,

31 water quantity alteration

32  
33 Species at Risk

34 Marine Ecosystems:

35 Stressors—Altered disturbance regimes, engineered structures, habitat

36 alteration, non-native invasive species, resource extraction/introduction,

37 water quality degradation

38  
39 Terrestrial Ecosystems:

40 Stressors—Altered disturbance regimes, habitat alteration, external

41 development/land use change, non-native invasive species, park

42 development and management, water quantity alteration

1	Aquatic/Wetland Ecosystems:	
2	Stressors—Engineered structures, habitat alteration, non-native	
3	invasive species, nutrient enrichment, water quality degradation,	
4	water quantity alteration	
5		
6	Exotic Species/Disease	
7	Marine Ecosystems:	
8	Stressors—Altered disturbance regimes, climate change, habitat alteration,	
9	park development and management	
10		
11	Terrestrial Ecosystems:	
12	Stressors—Altered disturbance regimes, fire management, habitat	
13	alteration, non-native invasive species, park development and	
14	management, resource extraction/introduction, water quality	
15	degradation	
16		
17	Aquatic/Wetland Ecosystems:	
18	Stressors—Altered disturbance regimes, habitat alteration, non-native	
19	invasive species, park development and management	
20		
21	<i>Specific Indicators</i>	
22	Top level carnivores	Deer
23	Common species	Feral cows
24	Amphibian guild	West Nile virus
25	Pacific tree frogs	Chronic wasting disease
26	Freshwater fish community	Lizards/small mammals
27	Abalone	Owls
28	Mussels	Butterflies
29	Barnacles	Terrestrial invertebrates
30	Limpets	Tabling bees
31	Chitons	Pinnipeds
32	Anemones	Centrarchids
33	Bumble bees	Cetaceans
34	Ants	Bullfrogs
35	Tidewater goby	Bats
36	Shrimp	Earthworms
37	The Nature Conservancy species	Turkey
38	Sturgeon	Starlings
39	Rockfish community	Cowbirds
40	Songbirds—riparian, chaparral, coastal scrub	Pea fowl
41	Shorebirds	Water birds
42	Seabirds	Warm-water fish
43		
44	<i>Comments</i>	
45	The Biosphere/Faunal group selected the five most significant drivers and	
46	stressors for each indicator for each ecosystem. They defined temporal and	
	spatial scales to be 20 yrs and 20-50,000 acres (100 km for marine	

ecosystems), respectively. Participants suggested that the monitoring program be flexible, incorporate indicators at various levels of ecological organization, and include redundancy. Additionally, representative species from the following groups should be included as part of the indicator selection process:

- Common species,
- Charismatic species,
- Practical species (on-going or cooperative studies),
- Exploited species,
- Keystone species,
- Endemic species,
- Species with special legal status, and
- Alien species.

#### Biosphere—Vegetation Group

##### *Revised General Indicator List*

Species Richness and Diversity  
Native Species of Special Interest  
Species at Risk  
Exotic Species/Disease  
Vegetation Composition and Structure  
Community Assemblages  
Fragmentation and Connectedness  
Land Use Patterns  
Phenology  
Biological Processes (Species Interactions)

##### *Dominant Drivers and Stressors*

For each vegetation indicator, the dominant drivers and stressors are listed below.

##### Species Richness and Diversity

Drivers--Climate/weather, hydrology, natural disturbance, biological processes  
Stressors—Altered disturbance regimes, fire management, habitat alteration, land use change, non-native invasive species, water quantity alteration

##### Native Species of Special Interest

Drivers—Climate/weather, hydrology, natural disturbance, biological processes  
Stressors—Altered disturbance regimes, fire management, habitat alteration, non-native invasive species, water quantity alteration

1 Species at Risk

2 Drivers—Climate/weather, natural disturbance regimes, biological  
3 processes

4 Stressors—Altered disturbance regimes, disease, fire management,  
5 habitat alteration, non-native invasive species, water quantity alteration  
6

7 Exotic Species/Disease

8 Drivers--Natural disturbance, biological processes

9 Stressors—Altered disturbance regimes, disease, external  
10 development/demographics, fire management, habitat alteration, land  
11 use change, non-native invasive species, nutrient enrichment, park  
12 management, water quantity alteration, soil alteration  
13

14 Vegetation Composition and Structure

15 Drivers—Climate/weather, natural disturbance, biological processes

16 Stressors—Altered disturbance regimes, fire management, habitat  
17 alteration, land use change, non-native invasive species, water quantity  
18 alteration  
19

20 Community Assemblages

21 Drivers—Climate/weather, natural disturbance, biological processes

22 Stressors—Altered disturbance regimes, climate change, fire  
23 management, habitat alteration, land use change, non-native invasive  
24 species, water quantity alteration  
25

26 Fragmentation and Connectedness

27 Drivers—Natural disturbance

28 Stressors—Altered disturbance regimes, external  
29 development/demographics, fire management, habitat alteration, land  
30 use change, water quantity alteration  
31

32 Land Use Patterns

33 Drivers—None ranked high

34 Stressors—External development/demographics, habitat alteration,  
35 land use change, non-native invasive species, recreational use,  
36 resource extraction, water quantity alteration  
37

38 *Specific Indicators*

39 A combination of community assemblages/structure, species richness, and native species of  
40 special concern is needed to properly evaluate vegetative characteristics.  
41

*Comments* Spatial scale was defined to be at the park level or larger for the Biosphere/Vegetation group. Ratings for drivers and stressors apply only to parks where the indicators occur. Most group members felt it was not necessary to sort dominant drivers and stressors by ecosystem because their ratings would be similar across ecosystem types.

#### Atmosphere / Lithosphere Group

##### *Revised General Indicator List*

Air Chemistry - contaminants  
Air Chemistry - nitrogen/sulfur deposition  
Air Chemistry - ozone  
Air Chemistry - carbon dioxide, methane  
Air Quality - fine particles (human health, visibility concerns)  
Weather/Climate Change  
UVB  
Lightscapes  
Soundscapes  
Habitat Patterns/Surficial Processes  
Soil Biota  
Soil Chemistry and Contaminants  
Soil Structure and Texture  
Soil Erosion and Deposition (Paleoclimate)  
Shoreline Shifts  
Earthquakes  
Mass Wasting

##### *Dominant Indicators for Associated Drivers and Stressors*

For each relevant driver or stressor, the high-ranking indicators are listed below (rated 3 or higher on a scale of 1-5, 1 being the highest).

##### *Drivers*

###### Climate/Weather

Weather/climate change, soil erosion and deposition (paleoclimate), mass wasting, shoreline shifts, habitat patterns/surficial processes

###### Coastal Processes

Weather/climate change, soil erosion and deposition (paleoclimate), mass wasting, earthquakes, shoreline shifts, habitat patterns/surficial processes

###### Geologic Processes

Weather/climate change, soil erosion and deposition (paleoclimate), mass wasting, earthquakes, shoreline shifts, habitat patterns/surficial processes

1 Hydrology and Flooding

2 Weather/climate change, soil structure and texture, habitat patterns/surficial  
3 processes, earthquakes  
4

5 Nutrient Cycles

6 Weather/climate change, soil chemistry, soil structure and texture, flooding,  
7 nitrogen/sulfur deposition, habitat pattern/surficial processes  
8

9 *Stressors*

10 Air Quality Degradation

11 All air quality indicators, weather/climate change, soil chemistry  
12

13 Engineered Structures

14 Soil structure and texture, lightscapes, soundscapes, habitat pattern/surficial  
15 processes, mass wasting, earthquakes, shoreline shifts  
16

17 Fire Management

18 Air quality, weather/climate change, habitat patterns/surficial processes  
19

20 Climate Change

21 Air quality, weather/climate change, soil erosion and deposition  
22 (paleoclimate), mass wasting  
23  
24

25 The following stressors were not ranked: Altered Disturbance Regimes (Flooding), Disease,  
26 External Development/Demographics, Habitat/Geomorphic Processes, Land Use Change, Non-  
27 native Species Invasions, Nutrient Enrichment, Park Development /Operations, Park  
28 Management, Recreational Use, Resource Extraction, Water Quality Degradation, and Water  
29 Quantity Alteration.  
30

31 High priority broad-scale indicators include:

- 32
- 33 • Mass wasting,
- 34 • Soil erosion and deposition, and
- 35 • Habitat patterns/surficial processes.  
36

37 *Specific Indicators*

38 UVB

39 Lightscapes

40 Soundscapes

41 Habitat Pattern/Geomorphology

42 Paleoclimate

43 Evapotranspiration

44 Columnar Water Vapor

45 Hydrophobicity  
46

Other Soil Biota

Soil Carbon Content

Watershed Characterization

Landform Mapping

Mycorrhizae

Cryptobiotic crust

Depth to Bedrock

*Comments* The Atmosphere/Lithosphere group ranked indicators based on their relationship to drivers and stressors by examining all indicators for each driver or stressor. There was consensus among the group that the Air Resources Division (ARD) would have significant input on the Air Quality Indicators, so discussion was limited in this area. ARD standard protocols could be used for monitoring air quality. There was some difficulty differentiating among Engineered Structures, Park Management, and Altered Disturbance Regimes. The group also noted that these resources are important for their inherent contribution to the overall health of a system and not as a resource for another resource, which is why they changed the broad-scale indicator Habitat to Surficial Processes.

### Hydrosphere Group

#### *Revised General Indicator List*

Water Chemistry  
Water Clarity  
Water Contaminants  
Pathogenic Bacteria  
Surface Water Dynamics  
Groundwater Dynamics  
Oceanographic Physical Parameters  
Flooding  
Waves  
Drought

#### *Dominant Drivers and Stressors*

For the drivers or stressors considered to be most important, the high-ranking indicators are listed below (rated 3 or higher on a scale of 1-5, 1 being the highest).

#### *Drivers*

##### Climate/Weather

Water chemistry, water clarity, water contaminants, pathogenic bacteria, surface water dynamics, groundwater dynamics, oceanographic physical parameters, flooding, waves, drought

##### Coastal Processes

Water chemistry, water clarity, pathogenic bacteria

#### *Stressors*

##### Climate Change

Water chemistry, pathogenic bacteria, surface water dynamics, oceanographic physical parameters, flooding, waves, drought

##### Habitat Alteration

Water chemistry

1		
2	Non-native Invasive Species	
3	No indicators ranked high for this stressor.	
4		
5	Resource Extraction	
6	Water clarity, surface water dynamics, groundwater dynamics, flooding	
7		
8	Engineered Structures	
9	Water chemistry, water clarity, surface water dynamics, groundwater	
10	dynamics, oceanography (currents), flooding, waves	
11		
12	Water Quality Degradation	
13	Water chemistry, water clarity, water contaminants, pathogenic bacteria	
14		
15	Water Quantity Alteration	
16	Water chemistry, water clarity, water contaminants, pathogenic bacteria,	
17	surface water dynamics, groundwater dynamics, flooding, drought	
18		
19	Air Quality Degradation	
20	No indicators ranked high for this stressor.	
21		
22	Recreational Use	
23	Water clarity, water contaminants, pathogenic bacteria	
24		
25	<i>Specific Indicators</i>	
26	Surface Water Chemistry	Oceanography
27	Ocean Water Chemistry	Flooding
28	Water Contaminants	Drought
29	Pathogenic Bacteria	Groundwater Dynamics
30	Surface Water Dynamics	Surface Water Use
31		
32	<i>Comments</i>	The Hydrosphere group considered three kinds of water: groundwater, surface
33		water, and ocean water. Limited consideration was given to groundwater
34		issues because of a lack of expertise in this area. In general, groundwater was
35		not considered by any of the groups and should be addressed as the process
36		continues. Several of the proposed relationships between indicators and
37		drivers and stressors were determined to be insignificant. These changes will
38		be reflected in the model revisions.
39		
40		

## Protocol Questionnaire Summary

Protocol Questionnaires were filled out by the resource realm workshop groups for the following indicators:

- Soil erosion/deposition
- Weather/climate
- Soil structure, texture, and chemistry
- Soil biota
- Shoreline shift
- Mass wasting
- Watershed characterization
- Landform mapping
- Stream channel characterization
- Air quality
- Surface Water Dynamics (flow, discharge)
- Pathogenic Bacteria
- Oil/Hydrocarbons (Water Quality)
- Nutrients (Water Quality)
- HAB (Harmful Algal Blooms)
- Clarity (Turbidity and Siltation)
- Oceanography
- Water Quality
- Surface Water Dynamics (Use)
- Lichens
- Vegetation Composition and Structure
- Riparian/Woodland Edge Plant Community
- Dune Habitat Assemblages
- Amphibians
- Small birds
- Trailmaster cameras for mammals
- Raptors

## General Discussion

The following comments were suggested as ways to enhance the SFAN Conceptual Model and improve the indicator selection process:

- Specifically define spatial boundaries and temporal scales for the SFAN parks.
- Characterize each driver and stressor to differentiate among similar categories.
- Clearly distinguish between a driver and a stressor.
- Match monitoring questions or management objectives with relevant indicators to provide context for indicator selection.
- Include more specific, local ecosystem components and processes in the model to create a stronger link to proposed indicators.

- Utilize standard techniques/protocols when they exist (e.g.—ARD, WRD).
- Focus the tasks for workshop participants on answering questions about specific indicators or sampling designs.

## **Future SFAN Vital Signs Program Development**

Over the next several months, the SFAN Steering Committee and I&M staff will be using information gained from the workshop to assist in the development of the SFAN's Vital Signs program. Specifically, workshop information will be used to:

- Develop an indicator database derived from completed protocol questionnaires.
- Prioritize Vital Signs indicators.
- Revise conceptual model components.
- Develop appropriate sampling designs and monitoring protocols.

These objectives are summarized below.

### Protocol Questionnaire Data Entry

Workshop participants were requested to complete at minimum priority categories highlighted on the protocol questionnaire form (Appendix E). Information from these key categories and any additional information provided will be reviewed by members of the SFAN Steering Committee and I&M staff. Indicator protocols used by individual parks will be integrated with those obtained from the workshop and entered into the Network database. Additionally, vegetation, faunal, and abiotic working groups will convene after the Vital Signs Workshop to refine the indicator protocol questionnaires by incorporating workshop comments and suggestions. All of this information will be used to prioritize indicators for the individual parks and for the SFAN.

### Prioritizing Vital Signs Indicators

Indicator prioritization is an iterative process. The SFAN prioritization process involves park scoping activities, network VS workshop review, initial prioritization based on indicator quality, and a second round of prioritization based on practical considerations such as cost and feasibility. The list of indicators and protocol questionnaires generated from this workshop will be used to select vital signs. Indicators will be ranked based on criteria determined by the Steering Committee. First-round criteria include management significance and ecological significance. The second round also includes cost effectiveness. (See Appendix E for descriptions of each criterion.) The resulting list of vital signs will be included in the Phase II draft report and include details of the process used to select SFAN Vital Signs. The list of Vital Signs is subject to change as fiscal resources and management issues change, and subsequent monitoring results provide feedback on the efficacy of the selected indicators. Monitoring program reviews will be conducted approximately every five years. Adjustments to the program then can be made accordingly.

1  
2 Conceptual Model Revisions

3 Comments, suggestions, and revisions listed in this document and expressed elsewhere will be  
4 amalgamated and then integrated into the Conceptual Model chapter of the Phase I revisions and  
5 the Phase II draft report. These reports will be peer reviewed starting in June 2003.  
6  
7

8 Sampling Design and Monitoring Protocols

9 Information obtained from protocol questionnaires will assist the SFAN in developing  
10 appropriate sampling designs and monitoring protocols for the Vital Signs Monitoring Program.  
11 Continued cooperation from workshop participants and scientists also will be necessary to ensure  
12 that a scientifically rigorous program is developed. Internal and external review will be  
13 conducted throughout this process as an essential part of the SFAN Vital Signs Monitoring  
14 Program.  
15  
16  
17  
18

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## **Glossary of Workshop Terms**

The following terms were used throughout the workshop as defined. Where noted by a footnote, definitions have been updated to be consistent with Service-wide usage of the terms.

Resource realms: Four major resource realms— biosphere, hydrosphere, atmosphere, and lithosphere—were used to conceptualize broad categories of interrelated ecosystem processes and components.

Ecosystems: Three main ecosystems were identified for the network of parks; terrestrial, wetland and marine. Within each ecosystem are sub-categories or forms. Marine forms include ocean, sandy beach, rocky intertidal, bay/estuary; wetland forms include running water, standing water and ground water; and terrestrial forms include grassland, shrubland, woodland and distinct landforms (e.g., serpentine).

<sup>1</sup>Natural ecosystem processes and drivers: Drivers are major external driving forces such as climate, fire cycles, biological invasions, hydrologic cycles and natural disturbance events (e.g., earthquakes, droughts and floods) that have large scale influences. Process examples include succession, deposition/accretion of soils, and marine currents.

<sup>2</sup>Anthropogenic stressors: Physical, chemical or biological perturbations to a system that are either a) foreign to that system or b) natural to the system but applied at an excessive (or deficient) level. Stressors cause significant changes in the ecological components, patterns and processes in natural systems. Examples include resource extraction, air quality degradation, land use changes, water quality degradation, water quantity alteration, human population increase or behavioral change, invasive species introductions, and fire regime alteration.

Socio-political forces: Laws, mandates, economic pressures and environmental perception influence political decisions bear upon anthropogenic stressors, and thereby, have a cascading effect on ecosystem function. These can include environmental laws (ESA, CWA, etc.), budgets, and changing social values.

Ecological effects: Are the physical, chemical and biological responses to drivers and stressors.

<sup>3</sup>Indicators: Also called “vital signs” or attributes, are any measurable feature of the environment that provides insights into changes in the state of the ecosystem. Indicators are intended to track changes in a subset of park resources and processes that are determined to be the most significant indicators of ecological condition of those specific resources that are of greatest concern to the parks. Indicators may occur at any level of organization including landscape, community, population or genetic levels, and may be compositional (referring to the variety of elements in the system), structural (referring to the organization or pattern of the system), or functional (referring to ecological processes).

Notes

<sup>1</sup> **Ecosystem drivers** are major external driving forces such as climate, fire cycles, biological invasions, hydrologic cycles, and natural disturbance events (e.g., earthquakes, droughts, floods) that have large scale influences on natural systems. **Natural ecosystem processes** include both external and internal forces and processes (e.g., herbivory, respiration, productivity).

<sup>2</sup> **Stressors** are physical, chemical, or biological perturbations to a system that are either (a) foreign to that system or (b) natural to the system but applied at an excessive [or deficient] level (Barrett et al. 1976:192). Stressors cause significant changes in the ecological components, patterns and processes in natural systems. Examples include water withdrawal, pesticide use, timber harvesting, traffic emissions, stream acidification, trampling, poaching, land-use change, and air pollution. **Anthropogenic stressors** are those perturbations to a system that directly result from human activity.

<sup>3</sup> **Attributes** are any living or nonliving feature or process of the environment that can be measured or estimated and that provide insights into the state of the ecosystem.

The term **Indicator** is reserved for a subset of attributes that is particularly information-rich in the sense that their values are somehow indicative of the quality, health, or integrity of the larger ecological system to which they belong (Noon 2002). Indicators are a selected subset of the physical, chemical, and biological elements and processes of natural systems that are selected to represent the overall health or condition of the system, known or hypothesized effects of stressors, or elements that have important human values.

**Vital Signs**, as used by the National Park Service, are the subset of indicators chosen by a park or park network as part of the Vital Signs Monitoring Program. They are defined as any measurable feature of the environment that provides insights into changes in the state of the ecosystem. Vital signs are intended to track changes in a subset of park resources and processes that are determined to be the most significant indicators of ecological condition of those specific resources that are of the greatest concern to each park. This subset of resources and processes is part of the total suite of natural resources that park managers are directed to preserve “unimpaired for future generations,” including water, air, geological resources, plants and animals, and the various ecological, biological, and physical processes that act on these resources. Vital signs may occur at any level of organization including landscape, community, population, or genetic levels, and may be compositional (referring to the variety of elements in the system), structural (referring to the organization or pattern of the system), or functional (referring to ecological processes).

1 Appendices (These items are linked to web-posted materials.)

2  
3 [Appendix A. PINN 2001 Vital Signs Workshop Summary](#)

4 [Appendix B. EUON/JOMU 2002 Vital Signs Workshop Summary](#)

5 [Appendix C. GOGA/PORE 2002 Vital Signs Workshop Summary](#)

6 [Appendix D. List of Workshop Participants](#)

7 Appendix E. Workshop Handouts

8 [Appendix F. Workshop Agenda](#)